Numerical Modeling of Dispersion at Salt Lake City Olympic Venues

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Objectives: The goal of our numerical modeling effort is to predict the dispersion of harmful materials released in or near an urban environment. This knowledge could prove useful in vulnerability assessments, mitigation strategies, sensor placement, and in understanding deficiencies of simpler dispersion models when applied to urban problems. As part of the CBNP program, both LANL and LLNL scientists have selected high probability target areas (e.g., Washington DC Mall area) at which to perform high fidelity tracer dispersion simulations. Currently, we are collaborating with the SCMIS team at LLNL and LANL to model some of the Salt Lake City Olympic venues. Initially, we have focused on the Delta Center, which is the venue for the Olympic figure skating competition. The results of this simulation are being used to characterize the source term for the SCMIS puff dispersion model and to aid in biological agent sensor placement around the Olympic venues. A larger area around the Delta Center including several hundred buildings will be simulated by the end of the summer.

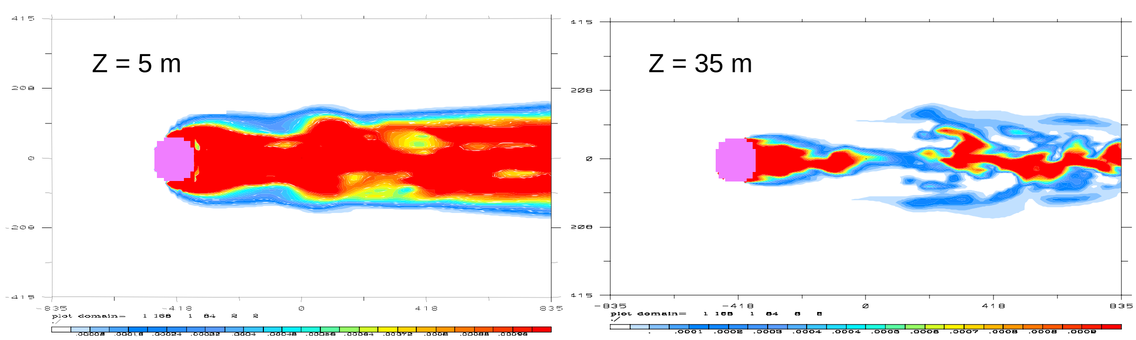

Figure 1: Instantaneous concentration contours of the tracer 10 minutes after the release at the Salt Lake City Delta Center, at heights of 5m and 35m, respectively.

Recent Progress: The case shown here simulates a chemical or biological agent release inside the Delta Center with the material being vented to the atmosphere through 16 elevated HVAC ventilation ducts. We have not modeled the interior dispersion, but instead are focusing on the downwind hazard posed by the venting of the toxin. By using the large-eddy simulation (LES) code HIGRAD, we are able to simulate the resolved-scale instantaneous concentration fluctuations and the time-averaged dispersion properties. The ambient meteorological conditions simulated were representative of a mid-latitudes winter day: neutral stratification, a surface temperature of 0 ^{o}C, and a power-law inflow velocity profile, with a velocity of 2.6 *m/s* at the building roof top. The LES code used in this simulation, HIGRAD, has a meteorological framework and uses a

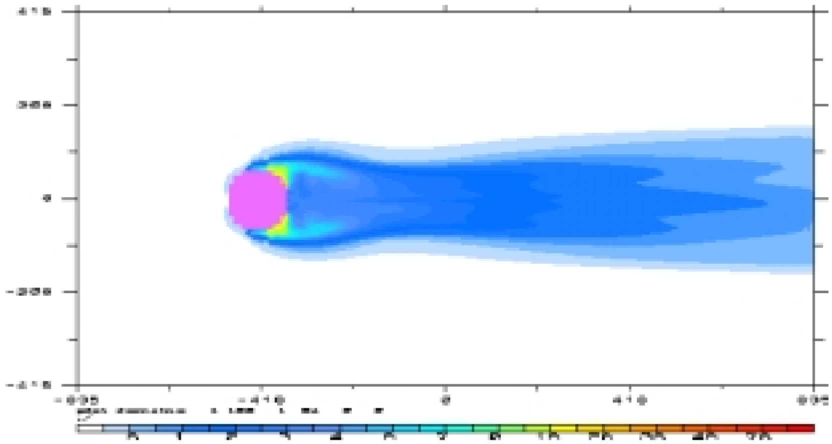

Figure 2: Ground-level dosage pattern around the Delta Center.

Smagorinsky subgrid closure method. The simulation was run on an SGI Origin2000 cluster using 105 processors, covering a 1.5*km* by 840*m* by 250*m* domain, with 10*m* horizontal and 5*m* vertical resolution. A massless tracer was continuously released for 10 minutes from 16 vents at a height of 35 meters. The code was run for an additional 30 minutes so that downwind concentrations and dosages could be computed. Figure 1 shows the instantaneous concentration contours at heights of 5m and 35m, at T=30 minutes, or 10 minutes after the end of the release.

The results of the simulation indicate that a significant amount of the tracer is trapped in the building wake, and as shown in Figure 2, produces high ground-level concentrations and dosages within the recirculation zone. The downwind concentration and dosage patterns are distinctly non-Gaussian, showing a double-lobe of maximum concentration downstream of the building edges. The results to be presented at an American Meteorological Society conference will include a comparison of instantaneous and time-averaged concentration and dosage patterns, and tracer flux through planes normal to the mean wind.

Future Outlook: In the near term, our goal is to simulate the flow patterns in a several kilometer area surrounding the Delta Center. This preliminary modeling study of the Delta Center was motivated by the SCMIS team's need to better characterize a source term for a vented rooftop release using their puff dispersion model. These results will be used for a comparative study with INPUFF (the dispersion model used in the Virtual Planner tool) for an elevated source with and without the building-induced downwash and recirculation effects. This study was our first step in a more expansive simulation of the area that will include the impact of hundreds of buildings, as well as topographic effects. We are currently digitizing the buildings surrounding the Delta Center using high resolution satellite images (Figure 3). We anticipate that the urban canyon and channeling effects in addition to the surrounding building wakes will dramatically change the dispersion patterns shown here. Knowledge of these effects on the dispersion of chemical and biological agents are key to threat analyses, mitigation studies, and the effective placement of sensors. In combination with the very high resolution simulations performed by the LLNL FEM3 code around a few buildings, these HIGRAD model simulations will allow for unprecedented transport and dispersion calculations ranging from the building scale to the urban scale. Other high probability target sites (e.g., the presidential conventions) could be studied with this modeling system as well.

Figure 3: Satellite image of urban area surrounding the Delta Center. We will simulate the flow field in this area using the HIGRAD fluid dynamics model.